

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
13 September 2001 (13.09.2001)

PCT

(10) International Publication Number  
**WO 01/66812 A2**

(51) International Patent Classification<sup>7</sup>: **C22C 21/00**

K7M 4J5 (CA). **PARSON, Nicholas** [GB/CA]; 23 Collegeview Crescent, Kingston, Ontario K7M 7J8 (CA).

(21) International Application Number: **PCT/CA01/00276**

(22) International Filing Date: **6 March 2001 (06.03.2001)**

(74) Agents: **EADES, Norris, M. et al.**; Kirby, Eades, Gale, Baker, P.O. Box 3432, Station D, Ottawa, Ontario K1P 6N9 (CA).

(25) Filing Language: **English**

(81) Designated States (*national*): **AU, CA, US.**

(26) Publication Language: **English**

(30) Priority Data:  
**60/187,835** **8 March 2000 (08.03.2000)** **US**

(84) Designated States (*regional*): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

(71) Applicant (*for all designated States except US*): **ALCAN INTERNATIONAL LIMITED** [CA/CA]; 1188 Sherbrooke Street West, Montreal, Québec H3A 3G2 (CA).

**Published:**

— *without international search report and to be republished upon receipt of that report*

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **MAROIS, Pierre, Henri** [CA/CA]; 38B Crescent Drive, Kingston, Ontario

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*



**WO 01/66812 A2**

(54) Title: **ALUMINUM ALLOYS HAVING HIGH CORROSION RESISTANCE AFTER BRAZING**

(57) Abstract: When using AA3000 series and AA1000 series aluminum alloys to produce extruded products for heat exchanger applications, by controlling the level of copper and nickel in the alloy to very low levels it is possible to produce excellent corrosion resistance both before and after a brazing cycle. To achieve these results, the copper content should be no more than 0.006% by weight and the nickel no more than 0.005% by weight. A typical alloy of the invention contains about 0.001 - 0.5% by weight manganese, 0.001 - 0.7% by weight iron, 0.001-0.02% by weight titanium, 0.001 - 0.3% by weight silicon, less than 0.006% by weight copper, less than 0.005% by weight nickel and 0.001-0.02% by weight zinc, with the balance consisting of aluminum and incidental impurities. No zinc addition to the alloy is required either by zinc spraying or by alloy addition.

Aluminum Alloys Having High Corrosion Resistance After BrazingTechnical Field

This invention relates to corrosion resistant aluminum alloys and, more particularly, to an AA3000 series type aluminum alloy having low levels of copper and nickel and showing excellent corrosion resistance after brazing.

Background Art

Aluminum alloys are well recognized for their corrosion resistance. In the automotive industry, aluminum alloys are used extensively for tubing because of their extrudability as well as the combination of light weight and high strength. They are used particularly for heat exchanger or air conditioning condenser applications, where excellent strength, corrosion resistance and extrudability are necessary.

The AA1000 series aluminum alloys are often selected where corrosion resistance is needed. Where higher strengths are required, the AA3000 series aluminum alloys are often used.

A difficulty with use of aluminum alloys in corrosive environments, such as heat exchanger tubing, is pitting corrosion. There are various methods currently in use for protecting tubing manufactured from clad sheet stock from corrosion. One of these consists of using a core alloy e.g. X800 or X900, which protects from corrosion through the formation of a dense precipitate band within the core adjacent to the cladding. This band corrodes preferentially to the rest of the core thereby increasing the life of the tube. This method is only applicable to sheet products due to the need for a clad layer of Al-Si alloy on the tube surface.

Alloys currently in use for brazed extruded tubing do not give good corrosion resistance unless the tubing is sprayed with zinc prior to brazing. This is typically carried out in-line at the extrusion press and is costly and undesirable from an environmental viewpoint.

Sircar, WO 97/46726, published December 11, 1997 describes a corrosion resistant AA3000 series aluminum alloy containing low copper, but high zinc and titanium. While this alloy provides reduced corrosion, its titanium content of 0.03

to 0.30% by weight raises the pressures required for extrusion, thereby lowering productivity.

U.S. Patent 5,286,316 (Wade) describes an alloy consisting essentially of 0.1 – 0.29% by weight manganese, 0.05 – 0.12% by weight silicon, 0.10 – 0.20%  
5 by weight titanium,  
0.15 – 0.25% by weight iron with the balance aluminum. This alloy contained very low levels of copper not exceeding 0.03% by weight, but again a quite high titanium content.

In Auran et al, EP 0899350, published March 3, 1999, a corrosion resistant  
10 alloy is described containing 0.10 – 0.40% by weight iron, 0.05 – 0.25% by weight silicon, 0.12 – 0.22% by weight titanium, less than 0.10% by weight manganese, less than 0.35% by weight copper and the balance aluminum.

In Auran et al, WO 99/04051, published January 28, 1999, another corrosion resistant alloy is described preferably consisting of 0.06 – 0.15% by  
15 weight iron, 0.05 – 0.15% by weight silicon, 0.03 – 0.08% by weight manganese, 0.10 – 0.18% by weight titanium, 0.10 – 0.18% by weight chromium, less than 0.01% by weight copper, 0.10 – 0.18% by weight zinc and the balance aluminum.

Jeffrey et al., CA 2,247,037 teaches extruding aluminum alloys having generally high zinc and low titanium into heat exchanges tubing. Corrosion  
20 testing was conducted on tubing which had not been exposed to furnace brazing conditions. An alloy with a low zinc content (0.0022%) failed the corrosion test.

It is an object of this invention to produce an aluminum alloy of the AA3000 type having excellent corrosion resistance when extruded into tubing and brazed without the need to add zinc by either zinc spraying or by alloy addition.

25

#### Disclosure of the Invention

It has been found according to the present invention that when using AA3000 series and AA1000 series aluminum alloys to produce extruded products for heat exchanger applications, by controlling the level of copper and nickel in  
30 the alloy to very low levels it is possible to produce excellent corrosion resistance both before and after a brazing cycle. To achieve these results, the copper content of the alloy is preferably no greater than 0.006% by weight and the nickel content

is preferably no greater than 0.005% by weight. These alloys typically contain up to about 1.5% by weight manganese, up to about 0.70% by weight iron, up to about 0.02% by weight titanium, up to about 0.30% by weight silicon, less than about 0.03% by weight zinc and the minimum copper and nickel contents as  
5 stated above. The balance consists of aluminum and incidental impurities.

According to a preferred embodiment, the alloy of the extruded product of the invention is an aluminum alloy containing about 0.001 – 0.5% by weight manganese, 0.001 – 0.7% by weight iron, 0.001-0.02% by weight titanium, 0.001 – 0.3% by weight silicon, less than 0.006% by weight copper, less than  
10 0.005% by weight nickel and 0.001-0.02% by weight zinc, with the balance consisting of aluminum and incidental impurities.

According to another preferred embodiment, the alloy of the extruded product of the invention contains less than 0.03% by weight zinc and has a corrosion resistance sufficient to pass a 20 day SWAAT corrosion test.

15 Although individual aluminum smelters may already exist that produce aluminum containing the above low levels of copper and nickel, the value of having a product with such low levels was not previously recognized. Accordingly, no effort has been made to isolate ingots during aluminum production such that a population of commercial aluminum ingots when re-heated  
20 for extruding into tubing will provide a melt containing less than 0.006% copper and less than 0.005% nickel. It is a feature of this invention that a population of aluminum alloy ingots used for extrusion into tubing will on average contain less than 0.006% copper and less than 0.005% nickel. Thus, a population of ingots is selected whereby the aggregate population has the above composition.

25 A typical alloy used in the present invention not only has very low levels of copper and nickel but may also be used without any deliberate additions of titanium or zinc. Thus, the extruded product may be devoid of any surface coating of zinc. The low level of titanium present is typically that remaining from grain refiner addition.

30 When these alloys are extruded into heat exchanger tubing, and especially micro-port tubing, they produce sufficient corrosion resistance on their own, thereby eliminating any need for the traditional zinc thermo-spraying step.

However, when these alloys are combined with a zinc spraying step the corrosion performance will be further improved. It is a particularly significant feature of these alloys containing very low levels of copper and nickel that they can be extruded into tubing and processed through a vacuum or inert atmosphere brazing cycle, while still exhibiting excellent corrosion resistance. These alloys also give excellent corrosion resistance for tubing used in mechanically assembled heat exchangers where no brazing cycle is used.

The extruded products of these inventions having high corrosion resistance are typically produced by the following steps:

- a) casting an ingot of an aluminum alloy as described above;
- b) homogenizing the ingot at a temperature between about 400°C and about 650°C;
- c) cooling the ingot to ambient temperature;
- d) re-heating the ingot and extruding into tubing.

When the tubing is subjected to a brazing cycle, this is done either in a vacuum or an inert atmosphere. For the brazing, the tubing is typically heated at a rate of about 5 to 30°C/min up to a temperature of about 585 to 615°C followed by rapid cooling.

## Best Mode For Carrying Out The Invention

### Example 1

A series of alloy compositions based on AA3102 aluminum alloy were D.C. cast as 4" diameter ingots. These had fixed iron, silicon and manganese contents but contained incremental additions of copper and nickel. The titanium was present only from grain refiner addition and was not a deliberate alloy addition. There was no deliberate addition of zinc and a background level of 0.005/0.006 wt% was present in the aluminum used to make up the melt. Also included was a commercially produced AA3102 alloy. The latter was cast as a 6" diameter ingot.

These alloy compositions are shown in Table 1 below:

Table 1

Cast	H309	H310	H311	J370	J371	J372	Commercial 3102
Si	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Fe	0.44	0.45	0.44	0.44	0.44	0.45	0.44
Cu	0.001	<0.001	0.001	0.006	0.013	0.022	<0.02
Mn	0.23	0.23	0.23	0.23	0.23	0.23	0.24
Zn	0.005	0.005	0.005	0.006	0.006	0.006	<0.02
Ni	0.001	0.002	0.0052	0.0009	0.001	0.001	<0.01
Ti	0.008	0.01	0.007	0.008	0.007	0.007	
Brazed Performance	0/5	0/5	2/5	4/5	5/5	5/5	5/5
As Extruded Performance	0/5	0/5	0/5	0/5	5/5	5/5	5/5

5

The ingots were homogenized for 4 hrs. at 620°C and cooled at 150°C/hr to room temperature. The metal was extruded into a 0.25 inch diameter round tube having a wall thickness of 0.016 inch using normal extrusion conditions and the product was air cooled to room temperature. The tubing was cut into 8 inch lengths. Five lengths of each alloy were given an inert atmosphere brazing cycle consisting of 20°C/min up to 625°C followed by fast cooling to room temperature, and five were kept in the as-extruded condition. The tubes were then exposed to a corrosive environment in a SWAAT cabinet according to ASTM spec #G85 – Annex A3. After twenty days exposure the tubes were removed and checked for perforation using compressed air at a pressure of 80 psi. The table above lists the number out of five that perforated for the brazed and non brazed conditions. In the non brazed condition no tubes failed providing the copper content was 0.006 wt% or less. After a brazing cycle no tubes failed providing the copper content was less than 0.006 wt% and nickel was less than 0.005 wt%. This shows that a long post brazed life can be achieved in a regular AA3102 Al-Mn type alloy extrusion if copper and nickel impurity levels are maintained below critical values (0.006 and 0.005 wt% respectively).

Example 2

A further series of four AA3102 type Al-Mn alloy compositions were D.C. cast as 6" diameter billets. The aluminum used to make up the melts was selected to have a copper content of 0.0012-0.0015 wt%. The nickel content was 0.0015 to 0.0019 wt%. The base level of zinc in the aluminum was 0.0021 – 0.0025 wt%. The four casts were alloyed so as to produce the following variants:

Low iron low zinc

Low iron high zinc

High iron low zinc

High iron high zinc

The compositions are shown in Table 2 below:

Table 2

Cast	Si	Fe	Cu	Mn	Zn	Ni	Ti
MNL	0.072	0.077	0.0012	0.21	0.0021	0.0015	0.0048
MNM	0.07	0.076	0.0012	0.23	0.0225	0.0015	0.0048
MNO	0.061	0.44	0.0015	0.23	0.0025	0.0018	0.0044
MNP	0.064	0.45	0.0015	0.23	0.0213	0.0019	0.0045

Silicon levels were maintained at ~0.07 wt% and Mn was maintained at ~0.23 wt% for all the casts. The titanium content was due to the addition of Ti/B grain refiner used to control the cast grain size and was not a deliberate alloy addition. The billets were homogenized using the same procedure as in Example 1 and were extruded into a 0.25 inch x 0.016 inch round tube. The tubing was cut into 8 inch lengths and given a simulated vacuum brazing cycle. The cycle consisted of a 25°C/min heat up to 500°C followed by 15°C/min to 600°C then 5°C/min to 615°C. The samples actually received about 2 min soak between 600°C and 607°C then were cooled in the furnace until 500°C (about 5 minutes) before being removed from furnace. A vacuum at about  $5 \times 10^{-5}$  Torr was used at brazing temperature.

The samples were then corrosion tested using SWAAT test as described in Example 1 and samples were taken out after 20 (2 tubes each), 25 (2 tubes each), 30 (2 tubes each) and 40 days (6 tubes each). The tubes were tested for perforation using compressed air at 80 psi. Table 3 below summarized the results:

Table 3

Cast	20 days	25 days	30 days	40 days
MNL	OK	OK	OK	5 out of 6 OK
MNM	OK	OK	1 out of 2 OK	4 out of 6 perf.
MNO	OK	OK	OK	5 out of 6 OK
MNP	OK	OK	1 out of 2 OK	All perf.

5 All of the tubes passed a 20-day SWAAT test, which was the criterion in Example 1, and also passed 25 days exposure. This supports the conclusion of Example 1 that an alloy with Ni less than 0.005 and Cu less than 0.006 wt% can pass a 20 day SWAAT post brazed. After thirty days exposure, failures were observed in the alloys containing the higher level of zinc. After 40 days exposure  
10 some perforations were encountered for all the alloys but the performance of the compositions with the higher zinc level was noticeably inferior. At the lower zinc level there was no measurable effect associated with changing the iron level from 0.07 to 0.44 and both alloys performed in an equivalent manner. This shows that  
15 SWAAT life post brazed for iron levels of 0.07 to 0.44 wt% and zinc levels of 0.002 to 0.025 wt%. Superior performance can be achieved (up to 30 days – no perforation) if the zinc content is kept <0.025 wt%.

Example 3

A series of three alloys were cast, homogenized and extruded into 0.014  
20 inch x 0.016 inch tubing in the same manner as in Example 2. A commercially produced AA3102 ingot was also included. The alloys had the compositions shown in Table 4 below:

Table 4

Cast	Si	Fe	Cu	Mn	Zn	Ni	Ti
MKX	0.08	0.08	0.0016	0.24	0.17	0.0022	0.0011
MKY	0.08	0.41	0.0017	0.24	0.17	0.0024	0.01
MGM	0.07	0.07	0.0022	0.24	0.17	0.0012	0.14
Production 3102	0.08	0.39	0.0179	0.21	0.014	0.0047	0.01

25

A total of ten 8 inch lengths of tubing were produced for each alloy. Half of these were given a 6% stretch to simulate the cold work associated with coiling/uncoiling and straightening operations, which would occur in an industrial



situation. The tubes were then exposed to a vacuum brazing cycle as in Example 2 before being SWAAT tested for 20 days.

All the tubes failed a 20 day SWAAT test by perforation as tested by compressed air.

5           In terms of composition the three experimental alloys all had low copper and nickel levels but had a deliberate zinc addition of 0.17 wt%. Alloy MGM also contained an increased Ti addition. The production alloy contained low zinc but contained copper >0.006 wt%. The results show that for vacuum brazed tubing, an alloy with low copper and nickel along with a deliberate zinc addition does not  
10       give 20 day SWAAT life.

Claims:

1. An aluminum alloy extruded product which has been subjected to a furnace brazing cycle, consisting essentially of an aluminum alloy of an AA1000 or AA3000 series containing less than 0.006% by weight copper and less than  
5 0.005% by weight nickel.
2. An aluminum alloy extruded product according to claim 1 comprising an extruded heat exchanger tube.
3. An aluminum alloy extruded product according to claim 2 wherein the alloy is of an AA3000 series.
- 10 4. An aluminum alloy extruded product according to claim 1 wherein the alloy contains up to about 1.5 % by weight manganese, up to about 0.70% by weight iron, up to about 0.02% by weight titanium, up to about 0.30% by weight silicon, less than about 0.006% by weight copper, less than about 0.005% by weight nickel and less than about 0.03% by weight zinc, the balance aluminum  
15 and incidental impurities.
5. An aluminum alloy extruded product according to claim 4 wherein the alloy contains about 0.001 to 0.5% by weight manganese, about 0.001-0.7% by weight iron, about 0.001-0.02% by weight titanium, about 0.001-0.3% by weight silicon, less than 0.006% by weight copper, less than 0.005% by weight  
20 nickel, about 0.001-0.02% by weight zinc, the balance aluminum and incidental impurities.
6. An aluminum alloy extruded product according to claim 1 which contains less than 0.03% by weight zinc and has a corrosion resistance sufficient to pass a 20 day SWAAT corrosion test.
- 25 7. An aluminum alloy extruded product according to claim 6 which is devoid of any surface coating of zinc.
8. A population of aluminum alloy ingots for use in producing extruded heat exchange tubes, said population of ingots consisting essentially of an aluminum alloy of an AA1000 or AA3000 series containing less than 0.006%  
30 by weight copper and less than 0.005% by weight nickel.
9. A population of ingots according to claim 8 containing less than 0.03% by weight zinc.

10. A process for producing aluminum alloy extruded product having high corrosion resistance which comprises selecting a population of ingots of an aluminum alloy of an AA1000 or AA3000 series whereby the aggregate population contains less than 0.006% by weight copper and less than 0.005% by weight nickel, melting said aggregate population of ingots and extruding the melt into tubing and thereafter subjecting the tubing to a furnace brazing cycle.

11. A process according to claim 10 wherein the tubing is subjected to a vacuum or inert atmosphere brazing cycle.

12. A process according to claim 11 wherein the brazing comprises heating the tubing at a rate of about 5 to 30°C/min up to a temperature of about 585 to 615°C followed by rapid cooling.

13. A process according to claim 10 wherein the extruded product contains less than 0.03% by weight zinc.

14. A process according to claim 10 wherein the copper and nickel contents of the alloy are controlled whereby the extruded product contains less than 0.006% by weight copper and less than 0.005% by weight nickel.

**HIS PAGE BLANK (USPTO)**

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
13 September 2001 (13.09.2001)

PCT

(10) International Publication Number  
**WO 01/66812 A3**

(51) International Patent Classification<sup>7</sup>: C22C 21/00.  
B21C 23/00

K7M 4J5 (CA). PARSON, Nicholas [GB/CA]: 23 Collegeview Crescent, Kingston, Ontario K7M 7J8 (CA).

(21) International Application Number: PCT/CA01/00276

(74) Agents: EADES, Norris, M. et al.; Kirby, Eades, Gale, Baker, P.O. Box 3432, Station D, Ottawa, Ontario K1P 6N9 (CA).

(22) International Filing Date: 6 March 2001 (06.03.2001)

(25) Filing Language: English

(81) Designated States (*national*): AU, CA, US.

(26) Publication Language: English

(84) Designated States (*regional*): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

(30) Priority Data:  
60/187,835 8 March 2000 (08.03.2000) US

Published:  
— with international search report

(71) Applicant (*for all designated States except US*): ALCAN INTERNATIONAL LIMITED [CA/CA]; 1188 Sherbrooke Street West, Montreal, Québec H3A 3G2 (CA).

(88) Date of publication of the international search report:  
3 January 2002

(72) Inventors; and  
(75) Inventors/Applicants (*for US only*): MAROIS, Pierre, Henri [CA/CA]; 38B Crescent Drive, Kingston, Ontario

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*



WO 01/66812 A3

(54) Title: ALUMINUM ALLOYS HAVING HIGH CORROSION RESISTANCE AFTER BRAZING

(57) Abstract: When using AA3000 series and AA1000 series aluminum alloys to produce extruded products for heat exchanger applications, by controlling the level of copper and nickel in the alloy to very low levels it is possible to produce excellent corrosion resistance both before and after a brazing cycle. To achieve these results, the copper content should be no more than 0.006% by weight and the nickel no more than 0.005% by weight. A typical alloy of the invention contains about 0.001 - 0.5% by weight manganese, 0.001 - 0.7% by weight iron, 0.001-0.02% by weight titanium, 0.001 - 0.3% by weight silicon, less than 0.006% by weight copper, less than 0.005% by weight nickel and 0.001-0.02% by weight zinc, with the balance consisting of aluminum and incidental impurities. No zinc addition to the alloy is required either by zinc spraying or by alloy addition.

# INTERNATIONAL SEARCH REPORT

Int. Application No  
PCT/CA 01/00276

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 C22C21/00 B21C23/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 C22C B21C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

CHEM ABS Data, EPO-Internal, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HUFNAGEL W: "Key to Aluminium Alloys, 4th Edition" 1992, ALUMINIUM-SCHLUESSEL = KEY TO ALUMINIUM ALLOYS, XX, XX, PAGE(S) 195,197 XP002176784 page 195; examples 1098D,1188,1193,1199 page 197; examples 3203,3010 ---	1-9
X	US 5 976 278 A (SIRCAR SUBHASISH) 2 November 1999 (1999-11-02) column 1, line 65 -column 3, line 57 column 4, line 10 - line 62; claims --- -/--	1-3,6-8, 10-12,14

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*G\* document member of the same patent family

Date of the actual completion of the international search

5 September 2001

Date of mailing of the international search report

20/09/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Patton, G

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/CA 01/00276

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 906 689 A (SIRCAR SUBHASISH) 25 May 1999 (1999-05-25) cited in the application column 2, line 12 - line 47 column 2, line 66 - column 4, line 32 column 5; examples M,N; table 1 claims ---	1-3,6-8
X	US 5 286 316 A (WADE KENNETH D) 15 February 1994 (1994-02-15) cited in the application column 2, line 6 - line 48 column 3, line 9 - line 34 column 5, line 60 - column 6, line 39; examples INV1, INV2; tables I, III column 11; example INV3; table VI claims ---	1-3,6-14
P,X	JP 2000 119784 A (SUMITOMO LIGHT METAL IND LTD) 25 April 2000 (2000-04-25) abstract examples 1-4,7,8,10,13,14,16,17,22-25,28-31,34,35,38-40; tables 1,3 ---	1-9
A	WO 91 14794 A (ALCAN INT LTD) 3 October 1991 (1991-10-03) the whole document ---	1-14
A	JP 2000 063970 A (NIPPON LIGHT METAL CO LTD) 29 February 2000 (2000-02-29) the whole document ---	1-14
A	EP 0 665 298 A (FORD MOTOR CO) 2 August 1995 (1995-08-02) the whole document -----	1-14

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/CA 01/00276

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5976278 A	02-11-1999	AU 9775898 A BR 9812712 A CN 1273614 T EP 1034318 A NO 20001664 A PL 339657 A WO 9918250 A	27-04-1999 22-08-2000 15-11-2000 13-09-2000 02-06-2000 02-01-2001 15-04-1999
US 5906689 A	25-05-1999	AU 3302697 A EP 0907757 A WO 9746726 A	05-01-1998 14-04-1999 11-12-1997
US 5286316 A	15-02-1994	AT 177792 T CA 2132840 A DE 69324037 D DE 69324037 T EP 0670913 A JP 7505448 T WO 9320253 A	15-04-1999 14-10-1993 22-04-1999 19-08-1999 13-09-1995 15-06-1995 14-10-1993
JP 2000119784 A	25-04-2000	NONE	
WO 9114794 A	03-10-1991	AU 7544091 A	21-10-1991
JP 2000063970 A	29-02-2000	NONE	
EP 0665298 A	02-08-1995	US 5478525 A CA 2135239 A DE 69406641 D DE 69406641 T ES 2108946 T	26-12-1995 18-06-1995 11-12-1997 02-04-1998 01-01-1998

Form PCT/ISA/210 (patent family annex) (July 1992)